NISTIR 89-4131

NDE PUBLICATIONS: 1985

Leonard Mordfin, Editor

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
and Technology
Institute for Materials Science
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Office of Nondestructive Evaluation
Gaithersburg, MD 20899

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NDE PUBLICATIONS: 1985

Leonard Mordfin

Office of Nondestructive Evaluation
Institute for Materials Science and Engineering
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(formerly National Bureau of Standards)
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1. Introduction

This is the ninth in a series of bibliographies of NBS publications on nondestructive evaluation (NDE). Previous reports in this series have been:

NBSIR 78-1557, "NDE Publications: 1972-1977",
NBSIR 80-2080, "NDE Publications: 1978",
NBSIR 81-2351, "NDE Publications: 1979",
NBSIR 81-2364, "NDE Publications: 1980",
NBSIR 83-2741, "NDE Publications: 1981",
NBSIR 85-3183, "NDE Publications: 1982",
NBSIR 86-3396, "NDE Publications: 1983", and
NBSIR 87-3552, "NDE Publications: 1984".

This report provides bibliographic citations for publications that appeared in the open literature during the calendar year 1985. Also included are citations for several publications that appeared in previous years but were not listed in the earlier compilations.

Almost all of these publications were authored by members of the NBS staff and include papers published in non-NBS media as well as papers and reports from the NBS publications series. A few were written for NBS by non-NBS authors. Many of the publications cited are based on research that was supported, in whole or in part, by the NBS Office of Nondestructive Evaluation.

These publications address a wide variety of NDE methods, both those that are well established in industry and some that are relatively new. For completeness, several publications dealing with technologies are are closely related to modern NDE, such as process monitoring and nondestructive materials characterization, have been included.

The format of this report is the same as that used previously. Brief, edited abstracts are provided for most of the publications cited. The bibliography and the abstracts comprise Section 2 of the report. The 131 entries of the bibliography are listed in alphabetical order by the surname of the first author.

Section 3 of the report is a subject index of the publications listed. This index is quite comprehensive and, when used together with the abstracts and the alphabetical bibliography, may be expected to enable readers to locate publications of interest without difficulty.

The last section of the report provides some assistance to readers wishing to obtain copies of specific publications listed.

2. Bibliography and Abstracts

1. **Auld, B. A., McFetridge, G., Riaziat, M., and Jefferies, S. Improved Probe-Flaw Interaction Modeling, Inversion Processing, and Surface Roughness Clutter,** Review of Progress in Quantitative Nondestructive Evaluation 4A, 623-634 (1985).

   A full inversion procedure is developed and illustrated for approximately rectangular-shaped EDM notches. Physical reasoning, based on the form of the flaw profile curves, is used to simplify the approach and to provide guidance in selection of the most suitable probe geometry. Other topics briefly addressed include possible improvements in the theory for the region with a/δ close to unity and for more realistic flaw shapes, inaccuracies due to errors in the probe scan path, and background clutter due to surface roughness, machining marks, and microstructure.

2. **Alperin, H. Study of Materials Subject to Impact,** NBS Reactor: Summary of Activities July 1983 through June 1984, NBS TN 1207, 82 (Feb. 1985).

   High resolution neutron diffraction measurements have been used to characterize specimens used for fracture dynamic studies. The principal causes of peak broadening are a decrease in the size of the coherent diffracting regions (particle size broadening) and internal strains. Of the two effects internal strains are the main cause. The magnitude of the resultant internal stress due to these strains is of the order of the yield stress in this material. Although the cube remained intact after impact, subsequent sectioning revealed many internal cracks.

3. **Barsky, M. and Hsu, N. N. Simple and Effective Acoustic Emission Source Location System.,** Materials Evaluation 43, No. 1, 108-110 (Jan. 1985).

   A simple acoustic emission (AE) source location system has been designed, constructed, and demonstrated. It will indicate the approximate location of an AE source inside a square area at a fast rate. The system requires no computer support, is totally self-contained, and can be built with inexpensive, readily available integrated circuits.

4. **Bentz, D. P. and Martin, J. W. Selection of a Spatial Sampling Procedure for Evaluating the Defect Area of a Coated Steel Panel,** J. of Coatings Technology 57, No. 726, 43-49 (Jul. 1985).

   Various spatial sampling procedures for determining the defect area of a coated panel are assessed using Monte Carlo techniques. Spatial sampling procedures have many advantages over the comparative visual standards currently used in evaluating defect area. In a previous report, a full grid sampling procedure was employed; the primary *disadvantage of this procedure was its long evaluation time. This procedure can be replaced by other sampling procedures with shorter sampling times as long as these other procedures are both accurate and easy to implement into actual practice. From the Monte Carlo simulations, systematic point sampling is found to be superior to both random point and stratified random point sampling in quickly estimating defect area proportion. Two other spatial sampling procedures may also find applications in coatings evaluation; linear sampling which effectively quantifies the corrosion area around a scribe mark and systematic ara sampling which provides valuable information on the defect size distribution as well as the total defect area.*

5. **Berger, H., Cutforth, D. C., Garrett, D. A., Haskins, J., Iddings, F., and Newacheck, R. L. Neutron Radiography, Section 12 in Nondestructive Testing Handbook, 2nd edition, Vol. 3: Radiography & Radiation Testing, L. E. Bryant and P. McIntire, eds., 532-563 (ASNT, 1985).**

   This section is a useful reference to practicing neutron radiographers and can serve as an introduction for students or conventional radiographers as well. The text includes helpful discussions on: neutron sources; moderation; collimation; techniques for neutron radiography; neutron imaging methods; and reference material concerning regulatory control, neutron radiography standards, and cross sections. A discussion of applications is also included, with some well-illustrated examples.

6. **Berk, N. F. and Hardman-Rhyne, K. Analysis of Beam Broadening SANS Data from Alumina Powder, NBS Reactor: Summary of Activities July 1983 through June 1984, NBS TN 1207, 36-37 (Feb. 1985).**

7. **Berk, N. F. and Hardman-Rhyne, K. A. Characterization of Alumina Powder Using Multiple Small-Angle Neutron Scattering. I. Theory, J. Appl. Cryst. 18, 467-472 (1985).**

   Microstructural parameters of high-purity alumina powder are determined quantitatively throughout the bulk of the material using small-angle neutron scattering techniques. A unified theoretical and experimental approach for analyzing multiple scattering data is developed to obtain values for particle size, volume fracture, and surface area. It is shown how particle size and volume fraction can be measured in a practical way from SANS data totally dominated by incoherent multiple scattering ("beam broadening"). The applicability of the formulations to polydispersed systems is discussed.

8. **Berk, N. F. and Hardman-Rhyne, K. H. The Phase Shift and Multiple Scattering in Small Angle Neutron Scattering: Application to Beam Broadening from Ceramics, NBS Reactor: Summary of Activities July 1984 through June 1985, NBS TN 1217, 68-72 (Dec. 1985).**

9. **Birnbaum, G., editor Nondestructive Evaluation: Technical Activities 1985, NBSIR 85-3187, 225 pp. (Nov. 1985).**

A review of the Nondestructive Evaluation Program at NBS for fiscal year 1985 is presented in this annual report.

10. **Birnbaum, G., White, G. S., and Vest, C. M. Laser Generated and Detected Ultrasound and Holographic Methods, Pressure Vessel and Piping Technology 1985 -- A Decade of Progress, 661-669 (ASME, 1985).**

    Several methods using laser radiation for nondestructive evaluation are discussed. These include the noncontact generation of ultrasonic waves by the interaction of laser radiation with metal surfaces, and the noncontact detection of surface deformation due to ultrasonic waves by laser interferometric and knife-edge techniques. In addition, optical holography, which has been used for the inspection of pressure vessels, is discussed. Several applications for laser generation of ultrasonic waves are described.

11. **Black, D. R., Bechtoldt, C. J., Placious, R. C., and Kuriyama, M. Three Dimensional Strain Measurements with X-Ray Energy Dispersive Spectroscopy, J. Nondestructive Evaluation 5, No. 1, 21-25 (1985).**

    A feasibility study was performed to show the ability of energy dispersive x-ray diffraction to measure three dimensional strain distributions in thick industrial materials. Photon energies up to 130 keV were used to guarantee penetration through the sample and curve fitting techniques applied to peak position determination. This system was used to measure the strain gradient through the thickness of a 9.5 mm thick cantilevered steel bar.

12. **Blackburn, D. L. Turn-Off Failure of Power MOSFETs, Proc. 16th Annual IEEE Power Electronics Specialists Conf., 429-435 (1985).**

    Experimental results of the failure of power MOSFETs during turn-off are discussed. A nondestructive measurement system is used, allowing repeated measurements of the failure characteristics as a function of various parameters to be made on single devices.

13. **Blau, P. J. Relationships between Knoop and Scratch Micro-Indentation Hardness and Implications for Abrasive Wear, Microstructural Science 12, 293-313 (1985).**

    Micro-indentation hardness test methods are an important tool for the evaluation of thin metallic layers and coatings. Both vertically moving and horizontally moving (scratch) indentation methods are currently in wide use. An investigation was conducted on pure samples of Cu, Fe, Sn, Cd, Ni, and Co and on 1010 steel, 52100 steel, 638 bronze, 688 bronze, and Nitinol (NiTi alloy) to study the relationships between vertical and horizontal (scratch) micro-indentation hardness numbers. Correlations between vertical and scratch hardness numbers varied with the testpiece material and the applied load. Microstructural features of the scratches were studied to analyze the cause of these variations.

The implications of these variations for abrasive wear/microhardness number correlations are discussed.

14. **Blau, P. J. and Olson, C. D. Application of Thermal Wave Microscopy to Research on the Sliding Wear Break-in Behavior of a Tarnished Cu-15 wt% Zn Alloy, Proc. of International Conf. on Wear of Materials, British Columbia, April 14-18, 1985, 425-431 (ASME, 1985).**

    Thermal wave microscopy (TWM) is a relatively new thermal acoustic imaging technique which can be used in a specially modified scanning electron microscope to detect subsurface features in metals and ceramics. Contrast in TWM images can be produced by differences in thermal conductivity or by subsurface defects of many kinds including pores, voids, and delaminations of layered structures. These sources of contrast make TWM a potentially valuable tool for wear research. The current paper describes how TWM was used to reveal wear process differences due to sliding direction reversal in a Cu-alloy covered by an oxide film.

15. **Blau, P. J. and Shives, T. R. Microindentation Hardness Testing, ASTM Standardization News 13, No. 1, 47-51 (Jan. 1985).**

    The paper reviews two common micro-indentation hardness testing methods for metals, highlighting sources of measurement errors, the significance of microhardness numbers, and both traditional and more unique applications of such testing. The trend towards automating hardness test methods is discussed.

16. **Blessing, G. V. Book Review: Treatise on Materials Science and Technology, Experimental Methods, Part B, edited by H. Herman; Materials Evaluation 43, No. 4, 359 (Mar. 1985).**

17. **Capobianco, T. E. A Review of Eddy Current Research at the National Bureau of Standards in Boulder, Colorado, Proc. 34th Defense Conf. on Nondestructive Testing, 164-173 (Charleston Naval Shipyard, Charleston, SC, 1985).**

18. **Capobianco, T. E. and Fickett, F. R. Precision Measurement of Eddy Current Coil Parameters, Review of Progress in Quantitative Nondestructive Evaluation 4A, 491-498 (1985).**

    Precision measurements of impedance, phase angle, and dissipation factor of commercial eddy current coils and specially prepared test coils by various techniques are described. The effect on the coil parameters of shorted turns, deformation, and ferrite defects is described.

19. **Capobianco, T. E., Moulder, J. C., and Fickett, F. R. Flaw Detection with a Magnetic Field Gradiometer, Proc. 15th Symposium on Nondestructive Evaluation, 15-20 (NTIAC, 1985).**

The authors describe a method for determining the normal component of the magnetic field gradient caused by a flaw. A novel feature of the measurement system is the use of a Superconducting Quantum Interference Device (SQUID). The SQUID provides more sensitivity than conventional detection methods, and the possibility of calibration based on a fundamental physical quantity: the flux quantum. Results are reported of a series of measurements on a fatigue crack and several manufactured defects in aluminum alloy specimens using the system.

20. **Carasso, A. S. and Hsu, N. N. Probe Waveforms and Deconvolution in the Experimental Determination of Elastic Green's Functions, SIAM J. Applied Mathematics 45, No. 3, 369-382 (Jun. 85).**

    We propose a new time domain method for the determination of the "impulse response" of linear systems. The technique centers around the use of specifically designed prove waveforms. This approach allows for continuous deconvolution, a powerful option in the presence of noise. We orient the discussion to the context of acoustic emission and elastic Green's functions and present several numerical reconstructions of sharp signals from smooth synthetic data.

21. **Carasso, A. S. and Hsu, N. N. The Inverse Gaussian Pulse in the Experimental Determination of Linear System Green's Functions, Trans. 2nd Army Conf. on Applied Mathematics and Computing, Report 85-1, 389-404 (U.S. Army Research Office, 1985).**

22. **Carasso, A. S. and Hsu, N. N. L^∞ Error Bounds in Partial Deconvolution of the Inverse Gaussian Pulse, SIAM J. Applied Mathematics 45, No. 6, 1029-1038 (Dec. 1985).**

23. **Case, E. D. and Glinka, C. J. Characterization of Microcracks in Yttrium Chromate (III) Using Small-Angle Neutron Scattering and Elasticity Measurements, J. Materials Science 19, No. 9, 2962-2968 (1984).**

    The mean crack radius, crack opening displacement, number density, and volume fraction have been estimated for a population of microcracks in polycrystalline YCr03 using small angle neutron scattering in tandem with elasticity measurements.

24. **Chang, Y. M. and Galowin, L. S. Aerial Thermography and Spot Radiometer Applications for Detecting Thermal Anomalies of Office Buildings, An International Conf. on Thermal Infrared Sensing for Diagnostics and Control (Thermosense VII), Proc. SPIE, Vol. 520, 178-189 (1985).**

    Aerial thermography and spot radiometer techniques were used for the assessment of roofs and heat loss through building envelopes of office buildings. The inspections were part of diagnostic programs developed by NBS to evaluate the thermal integrity of new and existing office buildings.

25. **Chang, Y. M., Grot, R. A., and Wood, J. T. Laboratory Design and Test Procedures for Quantitative Evaluation of Infrared Sensors to Assess Thermal Anomalies, NBSIR 85-3131, 86 pp. (Jun. 85).**

The report presents the description of the laboratory apparatus and preliminary results of the quantitative evaluation of three high-resolution and two low-resolution infrared imaging systems. These systems, which are commonly used for building diagnostics, are tested under various background temperatures for their minimum resolvable temperature differences at spatial frequencies from 0.03 to 0.25 cycles per milliradian.

26. **Chappell, J. NBS Advanced-Ceramics Expertise, Facilities Available to Industry, NBS Research Reports, NBS SP 680-4, 10-12 (Sept. 1985).**

Hardman-Rhyne uses the Bureau's 20-megawatt research nuclear reactor for small-angle neutron scattering and wide-angle neutron diffraction studies of green ceramics and finished materials to determine crystal structure and characterize microdefects. Freiman's group has developed a thermal-wave nondestructive technique for monitoring the microstructure of a ceramic during and after sintering. With modifications, the technique may one day prove useful as part of a production line system for monitoring and controlling the manufacturing process.

27. **Cheng, Y.-T., Blackman, M. J., Olin, J. S., and Ganoczy, M. Neutron Activation Autoradiography Study of Paintings, NBS Reactor: Summary of Activities July 1984 through June 1985, NBS TN 1217, 83-85 (Dec. 1985).**

28. **Choi, C. S. and Prask, H. J. Texture of Extruded Uranium Alloy by Neutron Diffraction, J. Applied Crystallography 18, 413-418 (1985).**

29. **Clark, A. V. and Moulder, J. C. Residual Stress Determination in Aluminum Using Electromagnetic Acoustic Transducers, Ultrasonics 23, No. 6, 253-259 (Nov. 1985).**

The residual stresses in a shrink-fit specimen were measured ultrasonically, using shear-horizonal (SH) waves transmitted and received by noncontacting electromagnetic acoustic transducers. The presence of stress induces a small change in the velocity of the SH-waves. The difference in velocities of orthogonally polarized SH-waves (acoustic birefringence) was measured with a simple time-interval averaging system; this velocity difference can be related to the difference of principal stresses. The presence of material anisotropy (texture) in the specimen also causes relative velocity changes comparable to stress-induced changes. A simple method was used to remove the anisotropy-dependent component of the total relative velocity change, thereby allowing a determination of residual stress. This method consisted of measuring the birefringence in unstressed reference specimens and subtracting it from the birefringence measured at stressed locations. For the specimen used here, good agreement between theoretical and experimental values of stress was obtained.

30. **Clark, A. V., Jr. and Moulder, J. C. Ultrasonic Determination of Principal-Stress Differences for a Slightly Anisotropic Residual Stress Specimen, Proc. 15th Symposium on Nondestructive Evaluation, 260-270 (NTIAC, 1985).**

We have used the acoustical birefringence technique to measure the difference of principal stresses in a specimen in a well-characterized state of residual stress. In this technique, the difference in arrival times of orthogonally polarized SH-waves is measured and then related to stress. Because the specimen is slightly anisotropic, the initial birefringence (B_0)*, can be as large as that caused by stress. Multiple measurements on unstressed reference specimens are necessary since* B_0 *can vary significantly from point to point. We used noncontacting EMATs, which allowed the measurements to be made quickly without introducing errors in arrival time due to couplant thickness variations.*

31. **Church, E. L., Vorburger, T. V., and Wyant, J. C. Direct Comparison of Mechanical and Optical Measurements of the Finish of Precision Machined Optical Surfaces, Optical Engineering 24, 388-395 (1985).**

This paper compares two methods of measuring the finish of precision machined optical surfaces: the well-established mechanical stylus gauge and a recently developed optical gauge using interference microscopy. Results are found to be in good quantitative agreement provided that appropriate filtering procedures are included in the data analysis.

32. **Clifton, J. R. Nondestructive Evaluation in Rehabilitation and Preservation of Concrete and Masonry Materials, Rehabilitation, Renovation and Preservation of Concrete and Masonry Structures, American Concrete Institute Special Publication 85-2, 19-29 (1985).**

The paper describes nondestructive evaluation (NDE) methods that can be used in assessing the condition of concrete and masonry materials and components in structures being rehabilitated or preserved. Metal reinforcement is also included. The appropriate use of NDE methods is discussed and a recommended approach to selecting NDE methods for specific situations is given.

33. **Clifton, J. R., Pizzutti Dos Santos, J. L., and Rossiter, W. J. Nondestructive Evaluation Methods for Assessing the Quality of Seams in Single-Ply Membranes, A Decade of Change and Future Trends in Roofing (Proc. 2nd International Symposium on Roofing Technology), 433-437 (NBS, 1985).**

34. **Clough, R. B., Schaefer, R. J., and Wadley, H. N. G. Acoustic Emission Monitoring of Laser Drilling, NDE of Microstructure for Process Control, H. N. G. Wadley, editor, 133-142 (ASM, 1985).**

Laser drilling is a rapidly growing manufacturing method. However, beam power spikes and intervening disintegration products can disrupt or diminish energy transmission to the hole site, resulting in variable hole depth. To improve this situation, a combination of acoustic *emission monitoring and laser settings has been investigated to improve hole depth prediction. Acoustic emission shows promise as an experimental method for study of directed energy beam-material interactions.*

35. **Clough, R. B. and Wadley, H. N. G. Acoustic Emission Monitoring of Dislocation Motion and Microfracture during Electron Beam Melting and Rapid Solidification of Aluminum Alloys, Review of Progress in Quantitative Nondestructive Evaluation 4B, 661-669 (1985).**

    Rapid solidification processing (RSP) is an emerging technology which can impart to engineering alloys superior surface properties, including enhanced wear and corrosion resistance. Acoustic emission is a candidate technique for in situ monitoring of RSP, with potential to detect defects, monitor processing conditions and provide fundamental information about the dynamics of rapid melting and resolidification. In this paper we investigate its application to the study of pulsed electron beam surface melting and rapid resolidification of aluminum alloys.

36. **Datta, S. K. and Ledbetter, H. M. Waves, Microstructures, and Effective-Medium Approximation, Mechanics of Dislocations, 213-223 (ASM, 1985).**

    The authors studied phase velocity of a plane wave propagating in an elastic medium with microstructure. Microstructures were inclusions or fibers, which were aligned or oriented randomly. Preferred orientation of the microstructure causes anisotropic macroscopic physical properties. A model predicts the macroscopic isotropic elastic constants for the case of random orientation and the macroscopic anisotropic elastic constants caused by preferred orientation.

37. **Dornfeld, D. A. Manufacturing Process Monitoring and Analysis Using Acoustic Emission, J. Acoustic Emission 4, No. 2/3, S123-S126 (Apr.-Sept. 1985).**

    Acoustic emission analysis has proven effective as a sensing methodology for machine tool condition monitoring. This paper reviews earlier work on machining monitoring and analysis and documents research done recently on wear and fracture detection for multiple insert machining operations (milling), chip form detection, analysis of the milling process, and tool fracture and wear modeling based on analysis of acoustic emission generated during machining.

38. **Dornfeld, D. A. and Pan, C.-S. A Study of Continuous/Discontinuous Chip Formation Using Acoustic Emission, NDE of Microstructure for Process Control, H. N. G. Wadley, editor, 197-206 (ASM, 1985).**

    Chip formation control is an important problem in unmanned machining operations. Chip formation conditions can change during machining, especially with single-point turning. Conditions of feed-rate-induced segmented chips correlate well with the count rate of acoustic emission (AE). The sensitivity of AE signals to chip congestion or entangling due to continuous chip formation is illustrated.

39. **Ehrstein, J. R., Downing, R. G., Stallard, B. R., Simons, D. S., and Fleming, R. F. Comparison of Depth Profiling of (10)B in Silicon Using Spreading Resistance Profiling, Secondary Ion Mass Spectrometry, and Neutron Depth Profiling, Semiconductor Processing, ASTM STP 850, 409-425 (1984).**

Depth profiling of intentional dopants is an important measurement in the semiconductor industry both for process and device modeling and for process control. A comparison of (10)B implants into silicon as measured by spreading resistance profiling, secondary ion mass spectrometry, and by neutron depth profiling is presented. The boron implantations were done at several fluences and energies into bare silicon and through several thicknesses of thermally grown oxides. Sources of error and their relation to observed differences among the techniques are discussed.

40. **Eitzen, D., Hsu, N., Carasso, A., and Proctor, T. Deconvolution by Design - An Approach to the Inverse Problem of Ultrasonic Testing, Review of Progress in Quantitative Nondestructive Evaluation 4A, 179-188 (1985).**

The authors present preliminary results on a new approach to characterizing flaws using ultrasonics. The approach takes advantage of the fact that they have control over the time waveform of the probing pulse in an ultrasonic test. It also takes advantage of some special properties of the inverse Gaussian function and an effective, stable, continuous deconvolution procedure which is based on the special function. The procedure also has the special feature that the error in the resultant of the deconvolution, which contains all available information about the flaw-scatterer, can be estimated in a powerful way. First they present the problem formulation and the analytical reasoning. They then discuss the inverse Gaussian function, the deconvolution procedure based on the probe function, and point out some of the special features of the probe function and the procedure. They also present some numerical tests and results using the procedure, demonstrate that the tools necessary to implement the procedure are within grasp, and present some preliminary experimental results.

41. **Elkind, B. J., Rosen, M., and Wadley, H. N. G. Ultrasonic Characterization of Microstructurally Modified Surfaces of Steels Subjected to Electron-Beam Irradiation, Proc. 11th World Conf. on Nondestructive Testing, Vol. 3, 1633-1640 (ASNT, 1985).**

A nondestructive method is presented for the determination of depth and elastic properties of modified surface layers. The parameters can be observed as variations in velocity with changes in frequency of Rayleigh surface waves. As a test of this technique, studies were conducted on plain carbon steel that had been subjected to electron-beam treatment for the creation of thin, microstructurally modified surface layers. On samples with a rapidly solidified, martensitic surface layer on a pearlitic substrate, the Rayleigh velocity varied from 2984 m/s at low *frequency (deep penetration into the substrate) to 2960 m/s at high frequency (penetration confined only to the surface layer).*

42. **Evans, L. and Yee, K. W. Alternatives for Sensing Tool Wear in Peripheral and Slot End-Milling, Technical Paper MS85-1001, 18 pp. (Society of Manufacturing Engineers, 1985).**

Cutting power, feed force, and Drill-Up, an instrument based on time-domain vibration analysis, are examined as three alternatives for sensing tool wear during peripheral and slot milling for heavy cuts in two steels of different hardnesses using 1/2-inch diameter high-speed steel and mills. Feed force is shown to be a viable method of sensing wear in both the hard and soft steels, for both peripheral and slot end milling. The original wear version of Drill-Up may be used to detect wear in peripheral milling; for slot milling it may be possible to use a more sensitive version. Cutting power is a good method for peripheral milling and it is less expensive and more practical to implement than feed force, but it may have insufficient sensitivity for slot-milling of the softer steel.

43. **Fick, S. E., Hsu, N. N., and Proctor, T. M. The Design and Calibration of a Novel Piezoelectric Point Contact High Fidelity Ultrasonic Transducer, Proc. 11th World Conf. on Nondestructive Testing, Vol. 2, 891-893 (ASNT, 1985).**

We report here the successful use of a specially-designed piezoelectric transducer to generate normal forces of known waveform over small well-defined areas of the surfaces of solid media. We explain how transducer design features previously verified in tests of the transducer as a receiver also allow the transducer to be used as a source with performance characteristics superior to those of several other methods of transduction. We conclude with a discussion of one of the techniques by which the transducer can be calibrated.

44. **Fickett, F. R. and Capobianco, T. E. Magnetic Field Mapping with a SQUID Device, Review of Progress in Quantitative Nondestructive Evaluation 4A, 401-410 (1985).**

Results of preliminary measurements using a SQUID (superconducting quantum interference device) system to determine the magnetic near field of commercial eddy current coils are presented. The SQUID system offers some significant advantages over more conventional techniques in that very small field sensors can be used, and the calibration of the system is tied to the quantum of flux.

45. **Fields, R. J., Dobbyn, R. C., and Glinka, C. I. Microstructural Characterization by Small Angle Neutron Scattering, NDE of Microstructure for Process Control, H. N. G. Wadley, editor, 123-131 (ASM, 1985).**

A brief review of the NBS small angle neutron scattering (SANS) facility is given followed by examples of its application. The *examples cover precipitation of copper in steel, volume changes during deformation of high strength alloys, and creep cavitation. Some potential contributions of SANS to NDE are discussed.*

46. **Fields, R. and Mozer, B. Neutron Small Angle Scattering and Pole Figure Analysis of Crept Copper Specimens,** NBS Reactor: Summary of Activities July 1983 through June 1984, NBS TN 1207, 50-52 (Feb. 1985).

47. **Forman, R. A., Bell, M. I., and Mayo, S. Rapid X-Ray Topographic Examination of GaAs Crystals,** Defect Recognition and Image Processing in III-V Compounds, J. P. Fillard, editor, 55-62 (Elsevier, Amsterdam, 1985).

    The design of a low-cost, high-throughput x-ray topography system is described, and its use in the examination of commercial GaAs wafers is demonstrated. Double-crystal reflection (Bragg) topographs are obtained in two minutes and transmission (Laue) topographs in fifteen minutes, using copper radiation from a conventional fine-focus laboratory x-ray source. Reflection topographs of typical GaAs wafers using selected diffracting planes are presented and their relative sensitivity to various defects discussed.

48. **Forman, R. A. and Mayo, S. In Situ Alignment Procedure for X-ray Topography,** J. Appl. Cryst. 18, 106-109 (1985).

    A simple method for in situ alignment of samples in a double-crystal x-ray topography system is described. This method permits a specific crystallographic axis to be made coincident with the sample rotation axis used to set the Bragg angle. Surface reflection from approximately orthogonal crystallographic planes are required and tables of such planes suitable for alignment of cubic crystals are given. This procedure allows rapid setup for the other accessible surface reflection or transmission topographs.

49. **Fraker, A. C. Corrosion of Ammunition,** Proc. 34th Defense Conf. on Nondestructive Testing, 2-16 (Charleston Naval Shipyard, Charleston, SC, 1985).

    Problems associated with the nondestructive evaluation of corrosion of ammunition were discussed and expected types of corrosion were described. There is a need for the development of standard procedures for nondestructive evaluation of corrosion of ammunition so that corrosion can be detected and arrested before the damage becomes critical and repair becomes expensive. A number of nondestructive techniques are suitable for this purpose. The development of these techniques will contribute to standard inspection procedures and uniform quality assurance. Planned sampling procedures would permit selective NDE of ammunition corrosion. NDE could be used with, and would complement, existing inspection procedures.

50. **Gilsinn, D. E., Vorburger, T. V., Scire, F. E., Teague, E. C., and McLay, M. J. Surface Texture Characterization by Angular Distributions**

of Scattered Light, Review of Progress in Quantitative Nondestructive Evaluation 4B, 779-788 (1985).

The present paper describes ongoing work to develop an on-line optical measurement device and associated algorithms that perform optical scattering measurements of metal surfaces produced by milling, grinding, or lapping, analyze the resultant scattered data and deduce appropriate surface parameters that characterize the particular surfaces being examined.

51. Gilsinn, D. E., Vorburger, T. V., Teague, E. C., McLay, M. J., and Giauque, C. Surface Roughness Metrology by Angular Distributions of Scattered Light, Measurement and Effects of Surface Defects and Quality of Polish, SPIE 525, 2-15 (1985).

On-line industrial inspection of batch manufactured parts requires fast measurement techniques for surface finish quality. A system has been built to determine surface roughness by measuring the angular distributions of scattered light. The system incorporates data gathered from the angular distribution instrument and traditional surface stylus instruments. The paper describes the results of an experiment in which angular scattered data from surfaces with sinusoidal profiles was used to compute the surface R (sub a) and wavelength. Stylus measurements of these parameters were made separately. A comparative table is given of the computed and measured values. Estimates of uncertainties are also given.

52. Glinka, C. J., Sander, L. C., Wise, S. A., Hunnicutt, M. L., and Lochmueller, C. H. Determination of Pore Accessibility In Silica Microparticles by Small Angle Neutron Scattering, Analytical Chemistry 57, No. 11, 2079-2084 (1985).

53. Goulard, R. and Ray, S. R. Optical Tomography in Combustion, Advances in Remote Sensing Retrieval Methods, 71-91 (A. Deepak Pub., Hampton, VA, 1985).

The principles of tomography have only recently been implemented using visible light. Tomographic absorption measurements have a number of advantages over optical point measurement techniques. In addition to the evident potential for rapid two or three dimensional imaging with high temporal and spatial resolution, the technique is also attractive in terms of the signal to noise ratio, due to multiple measurements of any single space element. Experimental work on a high speed optical tomography system is presented, demonstrating the capability to measure the two dimensional distribution of temperature and OH concentration in a premixed methane flame within five milliseconds.

54. Greenberg, R. R. and Carpenter, B. S. High Accuracy/High Precision Determination of (235)U in Nondestructive Assay Standards by Gamma-Ray Spectrometry, Proc. of International Conf. on Nuclear Methods in Environmental and Energy Research (5th), Mayaguez, Puerto Rico, April 2, 1984, 644-656 (1984).

55. **Gvishi, M., Rosen, M., and Wadley, H. N. G. Acoustic Emission Characterization of the Martensitic Phase Transformation in NiTi,** Review of Progress in Quantitative Nondestructive Evaluation 4B, 651-659 (1985).

To determine the transformation sequence in NiTi alloy is difficult because of the truncation of pre-martensitic effects by the martensitic transformation. In this investigation the use of acoustic emission to monitor and characterize the transformation in bulk samples is explored. Furthermore, the aim was to determine the critical points and the kinetic parameters of the transformation, as well as to corroborate the acoustic emission results with electrical resistance and optical microscopy examination.

56. **Hardman-Rhyne, K. A. and Berk, N. F. Characterization of Alumina Powder Using Multiple Small-Angle Neutron Scattering. II. Experiment,** J. Appl. Cryst. 18, 473-479 (1985).

Small-angle neutron scattering techniques are used to obtain microstructural parameters of high-purity alumina powder. The particle size, volume fraction and surface area have been obtained and are compared to data from techniques such as laser light scattering, x-ray sedigraph and scanning electron microscopy.

57. **Hill, D. A. Radio Propagation in a Coal Seam and the Inverse Problem,** J. Research NBS 89, No. 5, 385-394 (Sept.-Oct. 1984).

The longwall method of coal mining in underground seams is very efficient in uniform seams, but coal seam anomalies can make the method unprofitable and unsafe. This paper describes the theoretical basis for detection of coal seam anomalies using medium frequency radio transmission over paths on the order of 200 meters in length. The key to the method is the sensitivity of the attenuation rate to changes in the coal seam parameters, such as height or electrical conductivity. From a large number of transmission paths, the principles of tomography can be used to reconstruct an image of the seam.

58. **Hord, J. Survey of Measurement Needs in the Chemical and Related Industries, NBS TN 1087, 107 pp. (Jul. 1985). Available from NTIS as PB86-110848. Also available from Supt. of Docs. as SN003-003-02671-9.**

A survey of measurement needs in the chemical and related process industries has been completed. The survey revealed strong demands for improved in-line and in-reactor measurements, in a processing plant environment, to improve process/product quality and to reduce costs. The data base includes instrument (sensor) technical specifications, service conditions, calibration and maintenance requirements, and marketing information.

59. **Hsu, N. N. Dynamic Green's Functions of an Infinite Plate - A Computer Program, NBSIR 85-3234, 67 pp. (Nov. 1985). Available from NTIS as PB86-143856.**

The report is a FORTRAN program to compute the Green's functions of an infinite plate. The Green's function is the fundamental solution of the transient elastic wave propagation problem. In general, the displacement field due to a point force of arbitrary time dependence can be computed by a convolution integration. Displacement produced by a dynamic force distributed over a finite area can also be computed by numerical integration using the Green's function as the kernel of the integral over the finite area. The computer program is made available mainly for its application to calibrate acoustic emission systems and sensors.

60. **Hsu, N. N. and Fick, S. E. Acoustic Emission Made Audible by Time Dilation of Digitally Recorded AE Signals, J. Acoustic Emission 4, No. 2/3, S311 (Apr.-Sept. 1985).**

61. **Hubbell, J. H. Photon Cross Sections 1 keV to 100 GeV: Current NBS Compilation, Trans. American Nuclear Society 50, 153-154 (1985).**

    NBS has for over three decades supplied photon cross-section and attenuation coefficient data in the x-ray and gamma-ray energy region to diverse medical, industrial, and scientific communities. These tables are based on evaluations of experimental and theoretical data from the literature, supplemented by some interpolative and original developments at NBS to fill in existing gaps in the available information.

62. **Isenhour, T. L. Automated Pattern Recognition: Self-Generating Expert Systems for the Future, J. Research NBS 90, No. 6, 521-523 (Nov.-Dec. 1985). Available from NTIS as PB86-165776.**

    Chemometrics and pattern recognition had their start in chemistry in the late 1960's. The three most important areas of future development will be expert systems, relational data bases, and robotics. It should now be possible to combine existing robotics and artificial intelligence software to create a system which will generate its own expert systems using relational data bases. The Analytical Director will be an artificial intelligence/robotic expert system for the analytical laboratory. The Analytical Director will develop, test, implement and interpret chemical analysis procedures. it will learn from its own experience, the experience of others and communicate what it has learned to others. The Analytical Director will be a self-generating expert system. The author believes that such systems will, in the future, provide all the advantages of pattern recognition, expert systems, and relational data bases in experimental settings.

63. **Ives, L. K. Extraction Replica Method for the Study of Surface Films, Transactions, American Society of Lubrication Engineers 28, No. 1, 87-90 (1985).**

    An extraction replica method is described by means of which thin solid films on worn surfaces may be removed from selected areas for examination in the transmission electron microscope. Scratches are made on *the worn surface with a pointed stylus. Displaced or loosened fragments of material are removed by means of a plastic extraction replica. After subsequent processing of the replica, sufficiently thin fragments can be examined by transmission electron microscopy, electron diffraction and allied methods.*

64. **Kasen, M. B. and Hicho, G. E. Handling Blunt Flaws in a Fitness-for-Service Assessment of Pipeline Weld Quality,** Proc. of the Fracture Mechanics Seminar School (3rd): Fracture Mechanics of Weldments, Apandelova, Yugoslavia, June 25-29, 1984, 339-354 (1985).

    The significance of porosity, slag and arc burns on pipeline integrity is evaluated by assessing the probability of their contributing to crack initiation and to accelerated crack growth during low cycle fatigue. Suggestions are offered for approaches to treating the presence of blunt flaws during field inspections of pipelines.

65. **Katzir, Y., Young, M., and Glaser, I. Pattern Recognition Using Incoherent OTF (Optical Transfer Function) Synthesis and Edge Enhancement,** Applied Optics 24, No. 6, 863-867 (15 Mar. 85).

    The paper describes a system for pattern recognition using an incoherent-optical correlator. The system uses optical transfer function synthesis to perform correlations with an edge-enhanced image of the object being sought. The resulting correlations are free of bias and show good discrimination between objects. In addition, the difficult or time-consuming computations are performed before the operation of the system; this reduces the amount of postprocessing by computer and should allow real-time operation at video rates.

66. **Kent, E. W., Shneier, M. O., and Lumia, R. PIPE (Pipelined Image Processing Engine),** J. Parallel Distrib. Comput. 2, No. 1, 50-78 (Feb. 1985).

    The Sensory-Interactive Robotics Groups of the National Bureau of Standards' Industrial Systems Division is designing and constructing an experimental multistage pipelined image processing device for research in machine vision. The device can acquire images from a variety of sources, such as analog or digital television cameras, ranging devices, and conformal mapping arrays. It can process sequences of images in real time, through a serial pipeline of operations, under the control of an external device. Its output can be presented to such devices as monitors, robot vision systems, iconic to symbolic mapping devices, and image processing computers.

67. **Kent, E. W., Shneier, M. O., and Lumia, R. Design and Function of the NBS Pipelined Image Processing Engine,** Proc. of Conf. on Vision '85, Detroit, MI, March 25-28, 1985, 8.40-8.57 (1985).

    See abstract for Item No. 66.

68. **Knab, L. I., Walker, H. N., Clifton, J. R., and Fuller, E. R. Fluorescent Thin Sections to Observe the Fracture Zone in Mortar,** Cement and Concrete Research 14, No. 3, 339-344 (May 1984).

The report deals with the use of fluorescent thin sections to observe the microstructural details of the fracture zone. A mortar is used to illustrate the technique. It is concluded that the technique has the potential of providing new information on the fracture zone in mortars and concretes, both near the surface and in the interior.

69. **Kriz, R. D. Systems for Monitoring Changes in Elastic Stiffness in Composite Materials. U.S. Patent No. 4,499,770, $1.00, 6 pp. (19 Feb. 1985). Available from Commissioner of Patents, Washington, DC 20231.**

Energy flux transmitted into a fiber/matrix composite structure is propagated through the structure in directions which vary depending upon the elastic stiffness condition of the composite. Degradation in elastic stiffness will result in variations in the direction of travel of the flux through the composite. By determining the direction of flux propagation in the composite, or the portion of the composite structure from which the flux exits, the condition of the structure, independent of the source of degradation, can be determined. In preferred embodiments the energy flux is ultrasound energy, while in preferred testing devices a single transmitting transducer is directed towards at least two receiving transducers, one located to receive some flux in the absence of stiffness degradation, and a second located to receive some flux which would have traveled through a degraded structure.

70. **Kriz, R. D. and Ledbetter, H. M. Elastic Representation Surfaces of Unidirectional Graphite/Epoxy Composites,** Recent Advances in Composites in the United States and Japan, **ASTM STP 864, 661-675 (1985).**

Unidirectional graphite/epoxy composites exhibit high elastic anisotropy and unusual geometrical features in their elastic-property polar diagrams. Based on Christoffel-equation solutions, we describe some unusual elastic-wave-surface topological features. Some new, unexpected results for graphite/epoxy include: a shearwave velocity that exceeds a longitudinal-wave velocity in the plane transverse to the fiber; a wave that changes polarization character from longitudinal to transverse as the propagation direction sweeps from the fiber axis to the perpendicular axis.

71. **Ledbetter, H. M. Monocrystal Elastic Constants in the Ultrasonic Study of Welds,** Ultrasonics 23, **9-13 (Jan. 1985).**

For studying welds ultrasonically, the importance of knowing the material's single-crystal elastic constants is explained. Where these constants are not known, some guidelines are given for estimating them from polycrystalline elastic constants such as Young's modulus and the shear modulus. The important case of (001) fiber texture is considered. Being transversely isotropic, the case exhibits five macroscopic *elastic constants, which are related to the three cubic elastic constants. From the five constants the angular variations of Young's modulus, the torsional modulus, and the sound velocities can be computed. For the same fiber texture, results are given for a standard well-characterized material--copper.*

72. **Ledbetter, H. M. Manganese Contributions to the Elastic Constants of Face Centred Cubic Fe-Cr-Ni Stainless Steel, J. Materials Science 20, 2923-2929 (1985).**

    The author determined experimentally the effect of manganese on the elastic constants of face centred cubic Fe-Cr-Ni alloys with chemical compositions near 304-type stainless steel. By a pulse-echo-overlap method, longitudinal and transverse soundwave velocities were determined in ten alloys containing up to 6% manganese. All the elastic stiffnesses decrease linearly with increasing manganese.

73. **Ledbetter, H. M. and Austin, M. W. Anomalous Low-Temperature Elastic-Constant Behaviour of Fe-20Cr-16Ni-6Mn, Metal Science 18, 539-542 (Nov. 1984).**

    For the high nickel content austenitic stainless steel the complete set of polycrystalline elastic constants between 295 and 4 K were determined ultrasonically.

74. **Ledbetter, H. M. and Austin, M. W. Texture in Stainless Steel Welds: An Ultrasonic Study, J. Materials Science 20, 1720-1724 (1985).**

    The authors studied texture effects in five AISI-316 stainless-steel welds. They measured nine independent ultrasonic velocities along the welds' principal axes. These velocities reveal a strong texture different from the fibre type usually attributed to these materials.

75. **Ledbetter, H. M. and Austin, M. W. Effects of Carbon and Nitrogen on the Elastic Constants of AISI Type 304 Stainless Steel, Materials Science and Engineering 70, 143-149 (1985).**

    Five elastic constants were determined by a pulse echo ultrasonic method.

76. **Ledbetter, H. M. and Austin, M. W. Elastic Constant Versus Temperature Behavior of Three Hardened Maraging Steels, Materials Science and Engineering 72, 65-69 (1985).**

    Elastic constants of three maraging steels were determined by measuring ultrasonic velocities. Annealed steels show slightly lower bulk moduli and considerably lower shear moduli than hardened steels.

77. **Linteris, G. T. and Persily, A. K. Low-Cost Measurement of the Air Leakage in Homes, Proc. of Summer Study in Energy Efficient Buildings, Santa Cruz, CA, August 22, 1982, 547-548 (1984).**

Simultaneous air infiltration measurements were performed in a group of fourteen nominally identical wood frame houses for three test periods. The results indicate more than a two to one variation in infiltrations between the houses. Comparisons are made between measurement techniques.

78. **Linzer, M., editor Ultrasonic Imaging 7,** Nos. 1, 2, 3, 4 (**Academic Press, Jan., Apr., July, Oct.** 1985).

    This journal provides for original papers concerned with the development and application of ultrasonic techniques, with emphasis on medical diagnosis. Papers deal with theoretical and experimental aspects of advanced methods and instrumentation for imaging, computerized tomography, Doppler measurements, signal processing, pattern recognition, microscopy, and measurements of ultrasonic parameters.

79. **Martin, J. W. and McKnight, M. E. Prediction of the Service Life of Coatings on Steel, Part 1: Procedure for Quantitative-Evaluation of Coating Defects,** J. Coatings Technology 57, No. 724, 31-38 (1985).

    A new procedure, based on spatial statistical techniques, is proposed and demonstrated for quantitatively evaluating the degradation state of steel substrate panels protected by an organic coating. Representative output from this procedure is presented. This output includes changes in the number, size, area, and location of defects as function of time. The proposed procedure is fully compatible with existing visual procedures. The advantage of the proposed procedure is its increased precision.

80. **Martin, J. W. and McKnight, M. E. Prediction of the Service Life of Coatings on Steel, Part 2: Quantitative Prediction of the Service Life of a Coating System,** J. Coatings Technology 57, No. 724, 39-48 (1985).

81. **Martin, J. W. and McKnight, M. E. Prediction of the Service Life of Coatings on Steel, Part 3: Categorizing Performance of Coating Systems on the Basis of Corrosion and Blister Patterns,** J. Coating Technology 57, No. 724, 49 (1985).

82. **Martin, J. W., McKnight, M. E., Bentz, D. P. A Computer Image Processing System for Quantitatively Evaluating Degradation in Building Materials,** Proc. 34th Defense Conf. on Nondestructive Testing, 135-141 (**Charleston Naval Shipyard, Charleston, SC,** 1985).

    A minicomputer-based image processing system has been coupled to both a thermographic and a video camera to quantify defects from images of building materials. Several applications to building materials are presented including the detection of delaminations in single-ply roofing membrane seams, the characterization of the extent of corrosion under pigmented organic coatings on metallic substrates, the determination of the roughness of a sandblasted metallic substrate, and the determination of the porosity in hardened cement paste.

83. **Mehrabian, R. and Wadley, H. N. G.** Needs for Process Control in Advanced Processing of Materials, J. Metals 37, No. 2, 51-58 (1985).

Recent advances in the synthesis of new materials with complex microstructures, coupled with an improved understanding of process/ microstructure/property relationships, has created a new challenge for NDE--the redirection of a technology originally conceived for flaw detection/characterization to the nondestructive measurement of process and microstructure variables during materials processing. This review shows how NDE techniques could play the sensor role in automated process control. The techniques, originally developed for detecting cracks, show merit in monitoring solidification. Other ultrasonic techniques show promise in characterizing temperature distributions and porosity.

84. **Mehrabian, R. and Wadley, H. N. G.** Needs for Process Control in Advanced Processing of Materials, Review of Progress in Quantitative Nondestructive Evaluation 4B, 839-858 (1985).

See abstract for Item No. 83.

85. **Mehrabian, R. and Wadley, H. N. G.** Needs for Process Control in Advanced Processing of Materials, NDE of Microstructure for Process Control, H. N. G. Wadley, editor, 1-15 (ASM, 1985).

See abstract for Item. No. 83.

86. **Mordfin, L.** NDE Publications: 1982, NBSIR 85-3183, 37 pp. (Jun. 1985). Available from NTIS as PB85-244069.

87. **Mordfin, L.** Nondestructive Evaluation, Chapter 30 in Materials and Processes, 3rd edition, J. F. Young and R. S. Shane, editors, 1495-1519 (Marcel Dekker, 1985).

The several sections of this chapter provide introductions to the basic principles of the NDE methods most widely used in modern industry plus several newer methods that hold promise for broad implementation in the near future. The final section of this chapter introduces the concept of inspectability and the particular responsibilities it imposes upon the design engineer.

88. **Moulder, J. C., Gerlitz, J. C., Auld, B. A., Riaziat, M., and Jefferies, S.** Calibration Methods for Eddy Current Measurement Systems, Review of Progress in Quantitative Nondestructive Evaluation 4A, 411-420 (1985).

Quantitative inversion of eddy current signals to obtain flaw sizes from actual measurements requires methods for calibrating eddy current measurement systems. In performing flaw-signal inversion it is not sufficient to know the phase of the flaw signal relative to liftoff: rather, the absolute phase of Delta Z is required. The authors explore three possible approaches to this problem: absolute electrical calibra-

tion of the measurement system, measurements of probe liftoff signals, and measurements on actual or simulated flaws. Air core, circular coils of rectangular cross section are used to facilitate comparisons of theory and observation. Liftoff measurements are found to agree with analytical solutions. Flaw signals for surface breaking flaws agree with the predictions of nonuniform-probe-field theory.

89. **Mozer, B. and Singhal, S. Neutron Diffraction Studies of Amorphous Alloys,** NBS Reactor: Summary of Activities July 1983 through June 1984, NBS TN 1207, 53-56 (Feb. 1985).

    Neutron small angle scattering and neutron diffraction measurements have been performed upon a number of amorphous alloy systems to characterize the structure of these alloys in the various states they traverse as a function of heat treatment which carries them from the amorphous state to the crystallographic state characteristic of the alloy in thermal equilibrium.

90. **Nguyen, T. Thermal-Wave Imaging of the Microstructure and Corrosion of Cold-Rolled Steel under Protective Coatings,** Industrial & Engineering Chemistry Product Research & Development 24, No. 4, 496-500 (ACS, Dec. 1985).

    The application of thermal-wave imaging studies of corrosion and microstructure of polished and rough cold-rolled steel under clear and opaque coatings is presented in this paper. Thermal-wave imaging is shown to clearly distinguish the corrosion products from the surface topographic features of steel substrate with or without a protective coating layer. Preliminary results also indicate that thermal waves can image the microstructure of cold-rolled steel under a coating. This technique is thus potentially a viable technique to detect and assess very early corrosion of steel protected by clear and pigmented coatings.

91. **Nguyen, T. and Byrd, W. E. Reflection/Absorption Fourier Transform Infrared Spectroscopy of the Degradation of Protective Coatings on Mild Steel,** Proceedings of the International Conference on Organic Coatings Science and Technology (11th), Athens, Greece, July 8-12, 1985, 235-252 (1985).

    The application of reflection/absorption Fourier transform infrared spectroscopy (FTIR-RA) for studying the degradation of two types of coating on steel after exposure to 40C/80% RH environments is presented in the paper. FTIR-RA results indicate the occurrence of (1) bond weakening in the polymer film, (2) dehydration, and (3) bond scissions after exposure for seven months. Polybutadiene coating specimens show not only bond weakening but also extensive degradation which results in the formation of various oxidized products and losses in unsaturation. FTIR-RA offers a powerful means for studies of the degradation processes, both in the bulk and at the interface of protective coatings on steel.

92. **Nguyen, T. and Byrd, E. Reflection/Absorption Fourier Transform Infrared Spectroscopy of Degradation of Coatings on Steel, Polymeric Materials Science and Engineering, Proc. ACS 53, 568-573 (1985).**

See abstract for Item No. 91.

93. **Nguyen, T., Byrd, E., and Tsao, A. Nondestructive Characterization of the Degradation at the Steel/Coating Interface Using Reflection/Absorption Fourier Transform Infrared Spectroscopy, Proc. 34th Defense Conf. on Nondestructive Testing, 148-163 (Charleston Naval Shipyard, Charleston, SC, 1985).**

Interfacial degradation of protective coatings on cold-rolled steel surfaces subjected to a corrosive environment was studied by reflection/absorption Fourier transform infrared spectroscopy. Epoxy, polyurethane, and polybutadiene coatings on steel samples were exposed to 40°C and 80% RH conditions up to eight months, and the spectra were taken at different time intervals. Under these conditions, the protective coatings weakened and dissociated their hydrogen bonds, and degraded in the main chains. The results showed that the method can be used to nondestructively characterize coatings and their interactions with the metal substrate, and to study chemical changes at the metal/coating interface resulting from corrosion.

94. **Nguyen, T. and Rosencwaig, A. Thermal-Wave Microscopy and Its Application to Imaging the Microstructure and Corrosion of Cold-Rolled Steel, Applied Surface Science 24, 57-74 (1985).**

Thermal-wave microscopy (TWM), which employs heat flow to probe variations in the thermal properties of solid materials, can provide micron-level resolutions of subsurface features of opaque samples. This paper describes the principle of TWM and reviews its applications in material science. Preliminary results indicate that TWM can image the microstructure of cold-rolled steel with or without a corrosion layer. The results also suggest that the technique can monitor and assess corrosion in its early stage of formation.

95. **Norton, S. J. and Wadley, H. N. G. Tomographic Reconstruction of Internal Temperature, Review of Progress in Quantitative Nondestructive Evaluation 4A, 309-318 (1985).**

The development of a sensor to measure internal temperature distributions of hot bodies would significantly improve the productivity and quality of materials processing. The approach under development is based upon the dependence of ultrasonic velocity upon temperature. To produce two-dimensional temperature maps, we exploit the tomographic approach originally developed as a medical imaging modality with x-rays and ultrasound.

96. **Ogburn, F. and Mandel, J. Interlaboratory Comparison of Gold Thickness Measurements, Plating and Surface Finishing 72, No. 9, 48-51 (Sept. 1985).**

Several factors contributed to the variability of gold thickness measurements during a round robin of 44 participating laboratories. The influence of individual factors and suggestions for improving the reliability of measuring the thickness of gold deposits with beta backscatter are presented.

97. **Parker, R. L., Manning, J. R., and Peterson, N. C. Application of Pulse-Echo Ultrasonics to Locate the Solid/Liquid Interface During Solidification and Melting of Steel and Other Metals,** J. Applied Physics 58, **No. 11, 4150-4164 (1 Dec. 1985).**

The velocity of sound and the density have values that are sufficiently different for liquid as compared to solid phases of metals and alloys to permit the use of pulse-echo ultrasonic techniques to locate the solid/liquid interface during solidification and melting. Experimental results are presented for pulse-echo observation of the melting and freezing of pure iron, stainless steel, and tin. Rapid grain growth in the solid phase can strongly attenuate the sound waves and can also produce backscattered waves which obscure the identification of the solid/liquid echo. Additionally, in alloys the presence of a "mushy zone" rather than a sharp interface further reduces the reflected signal. These signal/noise problems were successfully overcome by the use of a transducer spatial scanning technique with computer signal averaging that permits the interface to be located even in concentrated alloys.

98. **Polvani, R. S., Reeve, C. P., and Veal, R. C. Optical Test Method for Measuring Biaxial Deformations,** J. Testing and Evaluation 13, **No. 1, 69-73 (Jan. 1985).**

A new and simple method is described for the measurement of biaxial deformation with a resolution of 0.025 micrometer (1 microinch). The basis of this technique is an optical extensometer.

99. **Prask, H. J. and Choi, C. S. NDE of Residual Stress in Uranium by Means of Neutron Diffraction,** J. Nuclear Materials 126, **124-131 (1984).**

A neutron diffraction technique for the nondestructive measurement of subsurface residual stress gradients in textured metallurgical samples is described. The technique is applied to the characterization of stresses in an aluminum calibration sample and to two depleted uranium-alloy cylinders of differing thermomechanical histories. The results confirm the accuracy of the technique and that neutron diffraction now appears to be the only technique by which nondestructive characterization of subsurface residual stress in uranium is possible.

100. **Prask, H. J. and Choi, C. S. Nondestructive Characterization of Subsurface Residual Stress in Depleted Uranium,** NBS Reactor: Summary of Activities July 1983 through June 1984, **NBS TN 1207, 78-82 (Feb. 1985).**

We have demonstrated that energy-dispersive neutron diffraction is a viable technique for the measurement of subsurface residual stress in highly textured metallurgical samples.

101. **Prask, H. J. and Choi, C. S. The Nondestructive Determination of Near-Surface Residual Stresses in Depleted Uranium Alloys, NBS Reactor: Summary of Activities July 1984 through June 1985, NBS TN 1217, 15-20 (Dec. 1985).**

Last year we described a new technique, energy-dispersive neutron diffraction (EDND), by which the first nondestructive characterization of sub-surface residual stress in DU was achieved. Because of expected susceptibility to stress-corrosion cracking, and because of the difficulties encountered with stress measurements in this material by x-ray diffraction, we have sought to extend the EDND stress measurements to the surface region of DU. In the following, results are described for a stress-free, powder test sample and two production-type DU specimens.

102. **Reed, R. P., Kasen, M. B., McHenry, H. I., Fortunko, C. M., and Read, D. T. Fitness-for-Service Criteria for Pipeline Girth-Weld Quality, Welding Research Council Bulletin No. 296, 80 pp. (Jul. 84).**

Criteria have been developed for applying fitness-for-service analyses to flaws in girth welds. A critical fracture mechanics model was developed and verified. Procedures for constructing flaw acceptance curves based on this model are provided. A significantly improved ultrasonic method for detecting and dimensioning significant weld flaws was developed. The probability of crack initiation from blunt flaws was shown to be very low. Suggestions are offered for implementation of field inspection procedures and flaw acceptance criteria.

103. **Rosen, M., Ives, L., Ridder, S., Biancaniello, F., and Mehrabian, R. Correlation between Ultrasonic and Hardness Measurements in Aged Aluminum Alloy 2024, Materials Science and Engineering 74, 1-10 (1985).**

Sound wave velocity, ultrasonic attenuation, eddy current, and hardness measurements have been carried out on precipitation-hardening aluminum alloy 2024 subjected to a series of different pre-aging heat treatments prior to processing to T4, T351, and T851 tempers. For each temper the maximum hardness was found to correspond to a particular value of sound velocity. These results were correlated with electron microscopy observations of the microstructure. Ultrasonic attenuation was found to decrease consistently as hardness increased. This investigation demonstrated the feasibility of ultrasonic techniques for non-destructive evaluation and characterization of age-hardened aluminum alloys.

104. **Sanders, A. A. Some Trends in Optical Electronic Metrology, Proc. of the Measurement Science Conf., Long Beach, CA, January 19-20, 1984, 27-33 (1984).**

The use of optical related devices in high technology is expanding at a dramatic rate. Applications include the use of optical fibers in sensors, lasers in industrial processing and medicine, optical storage devices, non-destructive testing, etc. The Optical Electronics Metrology Group of NBS has the responsibility for developing the standards, measurement data, and methodology infrastructure for supporting much of this technology. The paper reviews some of the research conducted by this group, and some of the important technological applications in this area for the next few years.

105. **Schrack, R. A. Uranium-235 Measurement in Waste Material by Resonance Neutron Radiography,** Nuclear Technology 67, 326-332 (Nov. 1984).

The use of resonance neutron radiography as a means of monitoring the amount of (235)U in waste material is investigated. The observed uncertainty agrees well with an analytical model and ranges from 15% for the lowest concentration to 2.5% for the highest concentration. The effect of inhomogeneity of matrix and sample is determined and found to be in agreement with analytical models.

106. **Schramm, R. E. and Moulder, J. C. EMAT/Synthetic Aperture Approach to Thick-Weld Inspection,** Review of Progress in Quantitative Nondestructive Evaluation 4A, 225-232 (1985).

The paper describes developments in a system based on electromagnetic-acoustic transducers (EMATs) as an approach to automated nondestructive evaluation of thick weldments. Good signal-to-noise ratios were possible through careful design and the use of signal averaging. The long wavelength permits determination of through-thickness flaw depth from the amplitudes of scattered ultrasonic waves. The synthetic aperture technique further improved signal quality and yielded flaw localization through the weld thickness.

107. **Schramm, R. E. and Siewert, T. A. Weld Flaw Sizing Using Back-Scattered and Forward-Scattered Low Frequency Ultrasound,** Proc. 11th World Conf. on Nondestructive Testing, Vol. 2, 1286-1293 (ASNT, 1985).

Electromagnetic-acoustic transducers (EMATs) generating low frequency ultrasound can detect and size planar flaws in welds. The back-scattered signal carries information on the through-depth flaw size. Measurements indicated a sensitivity to flaw depth sizes as small as 0.5 mm. In accordance with theory, this signal saturated at about 2.5 mm. This is a very important size range, but it is desirable to extend this range to larger flaw sizes. Processing the signals from two receiver transducers on either side of a flaw demonstrated a sizing ability for artificial flaws up to 11 mm deep. This technique has also been successfully applied to welded plates, each containing intentional flaws such as inadequate joint penetration and incomplete fusion. The weld flaw sizes predicted by the EMAT signals and those determined by destructive metallography agree within 1 mm.

108. **Shorten, F. J., editor. NBS Reactor: Summary of Activities July 1983 through June 1984, NBS TN 1207, 163 pp. (Feb. 1985). Available from NTIS as PB85-184836. Also available from Supt. of Docs. as SN003-003-02643-3.**

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1983 through June 1984. The programs range from the use of neutron beams to study the structure and dynamics of materials to neutron radiography and nondestructive evaluation.

109. **Shorten, F. J., editor. NBS Reactor: Summary of Activities July 1984 through June 1985, NBS TN 1217, 178 pp. (Dec. 1985). Available from NTIS as PB86-167863.**

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1984 through June 1985. The programs range from the use of neutron beams to study the structure and dynamics of materials to neutron radiography and nondestructive evaluation.

110. **Smith, J. and Berger, H. Assessment of Nondestructive Evaluation Methods for Hoop-Wrapped Cylinders, NBSIR 85-3101, 29 pp. (Feb. 1985).**

Cracks have been found in the threads in the neck of hoop-wrapped composite cylinders used as part of air breathing apparatus. These cracks have led to leaking and rupture during normal operation. Therefore, a reliable nondestructive evaluation method was required to identify and remove from service any cracked cylinders. Several standard nondestructive evaluation methods were used and evaluated for the inspection of these cylinders. The eddy current techniques were found to be the most reliable and practical for this application. Radiography was found to be reliable but judged too complex and expensive for wide use in the field. Ultrasonic and acoustic emission techniques were found unsuitable.

111. **Smith, J. J., Rosen, M., Wadley, H. N. G., and Friant, C. L. Nondestructive Characterization of Rapidly Solidified Alloys by Ultrasonic Techniques, NDE of Microstructure for Process Control, H. N. G. Wadley, editor, 101-111 (ASM, 1985).**

An ultrasonic technique, utilizing laser generated ultrasound, has been developed to detect changes of sound velocity associated with microstructural transformations occurring in rapidly solidified melt-spun ribbon specimens. Elastic moduli, calculated from the ultrasonic measurements, were used to characterize the decomposition of extended solid solutions of aluminum-manganese alloys and the crystallization of amorphous metal alloys.

112. **Spal, R. Collimation of X-rays with Cylindrically Bent, Asymmetrically Cut Crystals, Nuclear Instruments and Methods in Physics Research A222, No. 1-2, 193-195 (1984).**

Sagittal and meridional collimation of x-rays from a monochromatic point source, using cylindrically bent asymmetrically cut crystals is studied. The optimum bending radius and the width of the angular acceptance window are derived analytically, while the degree of collimation is computed numerically.

113. **Swanson, P. L. Subcritical Fracture Propagation in Rocks: An Examination Using the Methods of Fracture Mechanics and Non-Destructive Testing, NBS-GCR-85-491, 267 pp. (Apr. 1985).**

Physical insight into the underlying mechanisms of rock fracture is obtained by application of several nondestructive testing (NDT) techniques in conjunction with subcritical crack-growth experiments on Westerly granite. The size and shape of the fracture process zone is estimated from (1) the location of acoustic-emission events, (2) measurement of surface deformation using holographic interferometry, and (3) measurement of the spatial distribution of ultrasonic-wave attenuation. Zone-size and shape estimates derived from the NDT measurements are compared with both in situ microscope observations of the fracturing process and microcrack-model predictions.

114. **[Swartzendruber, L. J.] Military Standard: Inspection, Magnetic Particle, MIL-STD-1949, 27 pp. (1 Aug. 1985).**

This standard establishes minimum requirements for magnetic particle inspection used for detection of discontinuities at or immediately below the surface of ferromagnetic material.

115. **Swartzendruber, L. J., Strauss, B. H., and McEleney, P. C. Magnetic Particle Inspection Standards, Proc. 34th Defense Conf. on Nondestructive Testing, 188-196 (Charleston Naval Shipyard, Charleston, SC, 1985).**

Some aspects of MIL-STD-1949, a new Military Standard for Magnetic Particle Inspection, published 1 August 1985, are reviewed. Although magnetic particle inspection is a rapid, effective, and relatively inexpensive method for nondestructive inspection of parts fabricated from ferromagnetic materials, the method contains many pitfalls for the unwary. Use of the revised Standard should result in improved control of the inspection process.

116. **Takagi, S., Chow, L. C., Brown, W. E., Dobbyn, R. C., and Kuriyama, M. Application of an X-ray Image Magnifier to the Microradiography of Dental Specimens, J. Dental Research 64, No. 6, 866-869 (Jun. 1985).**

A highly parallel incident x-ray beam combined with x-ray image magnification was used to obtain high-resolution microradiographs of dental specimens. Preliminary results obtained using a rotating anode x-ray generator show that limitations associated with conventional contact microradiography regarding (1) spatial resolution; (2) sample thickness; and (3) sample orientation, relative to the film, were significantly reduced.

117. **Tao, G. Y., Pella, P. A., and Rousseau, R. M. NBSGSC - A FORTRAN Program for Quantitative X-ray Fluorescence Analysis, NBS TN 1213, 124 pp. (Apr. 1985) Available from NTIS as PB85-206068. Also available from Supt. of Docs. as SN003-003-02653-1.**

A FORTRAN program was developed for performing quantitative analysis of bulk specimens by x-ray fluorescence spectrometry. The analysis of alloys, pressed minerals, and fused specimens can currently be treated by the program.

118. **Testardi, L. R., Norton, S. J., and Hsieh, T. Determination of Inhomogeneities of Elastic Modulus and Density using Acoustic Dimensional Resonance, Review of Progress in Quantitative Nondestructive Evaluation 4B, 877-880 (1985).**

We describe a method for the reconstruction of the spatial inhomogeneities of the elastic modulus and density of a structure using only the measured fundamental and overtone resonances. The analysis for one dimensional systems shows that acoustic dimensional resonances act as a filter on inhomogeneous materials and select only that Fourier component which is spatially coincident with the mode. This yields a simple yet precise analytical formalism for reconstructing broad as well as localized variations in materials samples and structures. We give the theory and describe two experimental confirmations in which temperature distributions and holes are quantitatively detected in noncontact fashion using only measured resonant frequencies.

119. **Testardi, L. R., Norton, S. J., and Hsieh, T. Determination of Inhomogeneities of Elastic Modulus and Density for One-Dimensional Structures Using Acoustic Dimensional Resonances, J. Applied Physics 56, No. 10, 2681-2685 (Nov. 1984).**

We derive a simple relation which allows the reconstruction of the inhomogeneity of the elastic modulus and density along a rod based only on the measured fundamental and overtone frequencies. The technique, analogous to one-dimensional tomography in the frequency domain permits the quantitative detection of both continuous and localized defects. Experimental tests using impressed temperature profiles and drilled holes are reported.

120. **Trevino, S. F. and Berk, N. F. Study of Plasma Spray Coatings by Small Angle Neutron Scattering, NBS Reactor: Summary of Activities July 1984 through June 1985, NBS TN 1217, 72-73 (Dec. 1985).**

121. **Wadley, H. N. G. (chairman) Acoustic Emission: Open Discussion, Review of Progress in Quantitative Nondestructive Evaluation 4B, 727-737 (1985).**

122. **Wadley, N. N. G., editor, NDE of Microstructure for Process Control, 206 pp. (ASM, 1985).**

123. **Worthey, J. A. Visual Clarity with a Black-and-White Scene, J. Illuminating Engineering Society 14, No. 2, 634-647 (Apr. 1985).**

Visual clarity experiments are usually done with colorful test objects, and it is generally concluded that the results of such experiments are related to the color-rendering properties of the illuminants involved. Nonetheless, it has been observed that a clarity difference between illuminants may be seen, even with black-and-white objects. An experiment was performed to measure differences of perceived clarity using only black-and-white fabric and black yarn as test objects. The differences measured seem to indicate a role for color in black-and-white vision, but not a pure clarity effect independent of illuminant color.

124. **Yee, K. W. and Evans, L. Drill-Up, an Alternative for On-Line Determination of End-Mill Wear, Proc. 13th North American Manufacturing Research Conference, 304-309 (Society of Manufacturing Engineers, Dearborn, MI, 1985).**

125. **Yolken, H. T. and Mehrabian, R. A National Forum on the Future of Automated Materials Processing in U.S. Industry: The Role of Sensors, Report of a Workshop (1st) Held at Santa Barbara, California on December 16-17, 1985, NBSIR 86-3341, 79 pp. (Dec. 1985). Available from NTIS as PB86-212040.**

This is the proceedings of the first of two workshops to identify and assess important issues affecting the competitive position of U.S. industry related to its ability to automate production processes for basic and advanced materials and to develop approaches for improved capability through cooperative R&D and associated efforts.

126. **Yolken, H. T., Mordfin, L., and Birnbaum, G. Institute for Materials Science and Engineering, Nondestructive Evaluation: Technical Activities 1985, NBSIR 85-3187, 225 pp. (Nov. 1985). Available from NTIS as PB86-182375.**

A review of the Nondestructive Evaluation Program at NBS for fiscal year 1985 is presented in this annual report.

127. **Young, M. Scratch Standards Should not be Used to Predict Damage Threshold, Laser Induced Damage in Optical Materials: 1982, NBS SP 669, 151-155 (Jan. 1984).**

128. **Young, M. Scratch Standard Is Not a Performance Standard, Proc. of Optical Fabrication and Testing Workshop, Cherry Hill, NJ, June 12-13, 1985, THAA4-1-THAA4-2 (1985).**

The history and description of the scratch standard is given showing that the scratch number should never be related to its width and that the standard is cosmetic only.

129. **Young, M. Scratch Standard Is Only a Cosmetic Standard, Laser Focus 21, No. 11, 138-140 (Nov. 1985).**

See abstract for Item No. 128.

130. **Young, M. and Johnson, E. G. Redefining the Scratch Standards, NBS TN 1080, 28 pp. (Feb. 1985). Available from NTIS as PB85-194736. Also available from the Supt. of Docs. as SN003-003-02635-2.**

The scratch standard (MIL-0-13830A) is a cosmetic standard that is effected by a visual comparison with a set of submasters that are in turn evaluated by comparison with a set of master standards. Both manufacture and certification of the submasters are somewhat unreliable. In this paper, the authors show that the submasters can be classified according to the relative power scattered at a relatively small angle. They have designed etched gratings with which to replace the submasters; these gratings have the appearance of scratches but diffract a broad peak between 5 and 10 degrees off the axis of the incident beam. The authors have classified some prototypes both by comparison with the master standards and by a photoelectric measurement; agreement between the two methods is good. The authors suggest that such gratings be used as the submasters and possibly that they be classified by a photoelectric rather than visual measurement.

131. **Young, M., Johnson, E. G., and Goldgraben, R. Tunable Scratch Standards, Measurement and Effects of Surface Defects and Quality of Polish, Proc. SPIE, Vol. 525, 70-77 (1985).**

See abstract for Item No. 130.

3. Subject Index

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NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET** *(See instructions)*	1. PUBLICATION OR REPORT NO. NISTIR 89-4131	2. Performing Organ. Report No.	3. Publication Date AUGUST 1989

4. TITLE AND SUBTITLE

NDE Publications: 1985

5. AUTHOR(S)

Leonard Mordfin

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

Bibliography, CY 1985

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

10. SUPPLEMENTARY NOTES

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14. NO. OF PRINTED PAGES

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15. Price

$12.95

USCOMM-DC 6043-P80

Jan 19, 2017